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Vegetable-Derived Nutraceuticals: Occurrence, Therapeutic Applications, and Role in Health and Nutritional Security

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ABSTRACT

India, which is ranked 102nd out of 123 countries in the 2025 Global Hunger Index, has serious problems with malnutrition and the rising prevalence of chronic diseases. In addition to offering vital macronutrients and micronutrients, vegetables also provide a variety of nutraceuticals, which are biochemicals with intrinsic physiological benefits. The many kinds of nutraceuticals present in common vegetables are examined in this article, together with their unique occurrence and significant medicinal advantages. Important categories covered include carotenoids (such as lycopene and beta-carotene), which are known to improve skin tone and scavenge free radicals; phenols and anthocyanins, which are essential phytonutrients that protect against oxidative damage and inflammation; glucosinolates, which are converted into isothiocyanates and indoles and have anti-tumour properties; lipoic acid, which detoxifies the liver; and prebiotics, which positively influence the gut microbiota. This article underscores the critical importance of cultivating and consuming nutraceutical-rich vegetable varieties to enhance national food and nutritional security, boost immunity, and effectively combat chronic illnesses.

Keywords: *Vegetables, Nutraceuticals, Therapeutic uses, Antioxidants, Disease prevention, Malnutrition, Food security*

1. Introduction

With a hunger score of 25.8, India is ranked 102 out of 123 nations in the 2025 Global Hunger Index study, placing it in the "serious" category. Vegetable crops have a significant role in eradicating malnutrition in the nation. Iron, zinc, vitamin A, and iodine deficiencies are serious concerns for the Indian people (Ahmad et al., 2020). Any portion of a plant that may be utilized in cooking or consumed raw as a salad is considered a vegetable. Numerous healthy phytochemical components found in vegetables lower the chance of developing chronic illnesses. A class of biochemicals called nutraceuticals is present in food items and may have physiological advantages. Along with several phytochemicals that help the body eliminate free radicals and boost the activity of gut microorganisms, vegetables are recognized for their antioxidant qualities. In order to improve national food security and lower the likelihood of chronic diseases among the populace, breeding goals for variety and hybrid development in vegetables have shifted from high yielding to a crop with high nutraceutical content (Femi-Adepoju et al., 2023). Vegetables are rich in fibers, vitamins, minerals, antioxidants, and phytochemicals that help the body fight off illnesses and develop immunity against diseases, vegetables are essential to national nutritional and food security. As per the recommendation of ICMR (Indian Council of Medical Research) 300 grams of vegetables (125gm leafy vegetables, 200gm tubers and 75 grams other vegetables) should be consumed by per person per day. Vegetables like globe, among others, are essential for meeting nutritional and mineral deficiency demands since they include various phyto-pigments, such as lycopene, carotenoids, and chlorophyll, which are precursors to the majority of vitamins. In addition to minerals and vitamins, vegetables also contain some biochemicals known as nutraceuticals that, when taken by humans, may have physiological benefits.

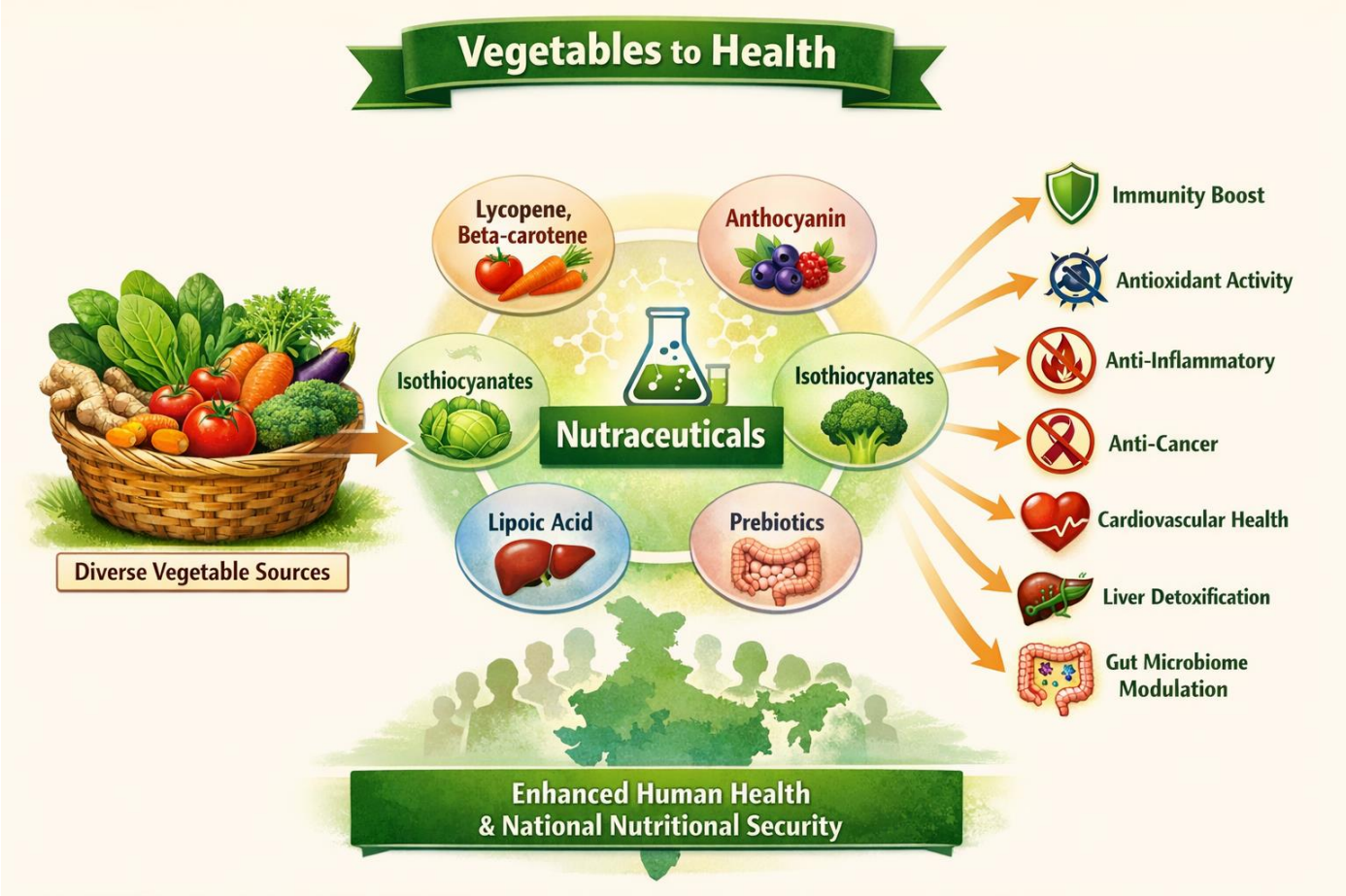

Figure-1: A central theme of "Vegetables to Health" illustrating the journey from diverse vegetable sources to specific nutraceuticals and their wide-ranging health benefits, culminating in improved human health and nutritional security

"Source: Author's own work."

2. Classification of vegetables

As far as we are aware, a vegetable is any portion of a plant that is eaten raw or after cooking. The following classification is based on the portion of the plant that is utilized as a vegetable (Koomer, 2009).

1. Root: Turnip, Radish, Beetroot, etc.
2. Leaves: Beat, Leaf, Lettuce, Spinach, etc.
3. Tubers: Tarro, Potato, etc.
4. Fruits: Tomato, Brinjal, etc.
5. Seeds: Lentils, Soyabean, Pea, etc.
6. Stem: Salary, Asparagus, etc.
7. Bulb: Onion, Garlic, etc.
8. Flower: Articulate, Broccoli, etc.

3. The occurrence of nutraceuticals in vegetables

Nutraceuticals are a class of compounds obtained from food that can provide both nutritional and medicinal benefits, also called as bioceuticals. These are mixtures with medicinal and nutritional potential derived from biochemicals found in nature. Numerous phytochemical substances with nutritional and therapeutic benefits have been found in various vegetable types; the table below lists the nutraceuticals found in vegetables.

Vegetables	Nutraceuticals
Green leafy vegetables	Vitamin C
Tomato, Watermelon	Lycopene
Garlic, Onion	Allyl Sulphides
Cole crops	Glucosinolates
Brinjal	Nasunin, caffeic acid
Lentils	Isoflavonoids
Asparagus	Rutin
Beetroot	Betanin
Celery	Luteolin
Sweet potato	Anthocyanin
Red chilli	Capsaicin
Turmeric	Curcumin

Table-1: Table Illustrating the Presence of Key Nutraceuticals in Selected Vegetables (Chauhan et al., 2013).

4. Using vegetable-based nutraceuticals

The Rig Veda has evidence for the use of vegetables and vegetable-derived products as treatment for a variety of illnesses. Vegetables or their byproducts have been used by humans to treat a variety of chronic illnesses since the Vedic era (Krepkova, et al., 2021). Recent research on vegetable nutritional and phytochemical profiling revealed the crops' richness and protection. The **table-2** lists few crops and their mineral concentration. Vegetables include phytochemicals and bioceuticals. Among the important families of secondary metabolites, carotenoids exhibit significant biological activity, such as scavenging free radicals, which improves skin tone and suggests potential as a treatment (Parulekar, et al., 2019). These compounds fall into two categories: hydrocarbons like lycopene, beta, and alpha carotene, and oxycarotenoids such as lutein and zeaxanthin. Phenols constitute a broad class of phytonutrients, vital in preventative medicine due to their defence against inflammation and oxidative tissue damage. Anthocyanins are responsible for the blue, crimson, purple, and orange hues of flowers, fruits, and foliage, and also possess antioxidant qualities. Glucosinolates, abundant in cruciferous plants, transform into isothiocyanates and indoles when the vegetables are chopped, a process that helps lessen the likelihood of tumour growth in organs like the liver, lungs, and digestive tract (Cao, et al., 2021) Lipoic acid acts as an antioxidant by quenching hydroxide radicals and is essential for liver detoxification as it shields glutathione and catalase (Koomer, 2009). Complementing these are prebiotics, which are beneficial dietary components that impact the host by specifically changing the composition and metabolism of gut microorganisms

Vegetables	Nutraceuticals	Therapeutic use	Source
Turmeric	Curcumin	Treatment and prevention for inflammation, diabetes and arthritis	A.Omara et al., 2010
Carrot	Beta carotene	Antiaging, anticancer and antidiabetic	Arya et al., 2019
Ginger	Zingiberene	Treatment of hyperglycemia, dizziness, diabetes	Unuofin et al., 2021
Turnip	Ferulic acid	Antioxidant, antiaging, antidiabetic	Ismael, 2022
Celery	Butylphthalide	Used for controlling high blood pressure	Keservani et al., 2010
Tomato	Lycopene	Anticancer, treatment of cardiovascular ailments	Parulekar et al., 2019
Artichoke	Silymarin	Prevent liver diseases	Rai et al., 2012
Egg plant	Nasunin	Cardiovascular diseases, skin blemishes	Singh et al., 2015

Table-2: Overview of Medicinal Properties and Sources of Nutraceuticals from Common Vegetables

Nutraceuticals	Taken via
Beta carotene	Kanji, gajar ka halwa
Lycopene	Tomato chutney, watermelon pulp
Lutein	Salads having green leafy vegetables
Phenols	Began bharta
Anthocyanin	Backed sweet potato stem
Flavonoids	Onion/ garlic pickle or chutney
Glucosinolates	Sauteed cole crops
Lipoic acid	Green vegetables salads
Nasunin	Brinjal
Prebiotics	Carrot, Tomato salads

Table-3: Ways for ingesting nutraceuticals **"Source: Author's own work."**

Crop	Variety	Character	Source
Chenopod	Bathua local	Ascorbic acid (60.6mg/100gm)	Gharibpour et al., 2021
Basella	Local Red	Carotenoids (10mg/100g)	Yadav et al., 2013
Radish	Pusa Jamuni	High Anthocyanin and vitamin C	Tripathy et al., 2021
Sweet potato	Bhu Sona	High beta carotene (14mg per 100gm)	Srinivasan et al., 2019
Carrot	Pusa Asita	High Anthocyanin content	Tripathy et al., 2021
Amaranthus	Pusa Kiran	Carotinoides (59mg/100g)	Yadav et al., 2013
Tapioca	Sree Visakham	466IU/ 100gm carotene content	www.ctcri.org

Table-4: Nutraceutical and Phytochemical Rich Varieties/ Hybrids:

Conclusion

Numerous diseases can be prevented by eating a balanced diet that includes the recommended quantity of vegetables. In addition to providing micro and macronutrients, vegetables also include several bioceuticals that the body needs to create immunity. Vegetables contribute to the country's increased food and nutritional security. Recent studies on the phytochemicals and intersecticles found in vegetables have presented nutritionists and pediatricians with serious challenges. Dietary micro and macro constituents are abundant in the majority of newly created varieties and hybrids. In the area of severe malnutrition, emphasis should be placed on expanding the availability of vegetables with high nutraceutical qualities. This will eventually lower the incidence of malnutrition in the nation and contribute to improving national food security in the years to come.

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